Traction Control Algorithm for a Formula Student Race Car

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Excessive tire slip reduces traction, efficiency and overall control. By minimizing tire slip to an optimal level, tire friction can be maximized. This thesis presents a traction control algorithm for the Bern Racing Team's all-wheel drive electric race car. The system aims to improve acceleration, control and efficiency by optimizing tire use, leading to better performance and higher scores at competitive events.

Motivation

The Bern Racing Team achieved good results in the 2022/2023 season thanks to a reliable car. However, the lack of any driver assistance systems resulted in excessive wheel spin, resulting in loss of grip, loss of control and increased energy consumption. The goal of this project therefore was to develop an algorithm that dynamically distributes the torque between the front and rear axle and limits the wheel speeds depending on vehicle speed.

Implementation

A comprehensive simulation model of the car was created in Simulink to develop the algorithm off-track. This model includes detailed components such as:

- Car body with front and rear suspension
- Tires modelled using a Pacejka tire model
- Wheel and gearbox inertia
- Motor modelled using data provided by the manufacturer
- Inverter with individual controllers for current and speed limitation

This detailed modelling allowed for precise tuning of the inverter parameters within the simulation environment, providing a solid starting point for subsequent testing and refinement on the actual vehicle.

The proposed algorithm calculates the torque set-points for each wheel and calculates the wheel speed limits for acceleration and regenerative braking. An INS/GNSS (Inertial Navigation System / Global Navigation System) is used to provide the best possible orientation, acceleration and speed estimates.

Results

A simplified model of the controller was tested on last season's car (**Figure 1**) together with the newly determined inverter parameters. This model only limited the wheel speeds and acted as a launch control. As shown in **Figure 2**, on slick tires and dry track conditions, the acceleration time from 0-100 km/h improved slightly from 3.16 s to 3.12 s, while the energy consumption dropped by 20.3 % from 64 to 51 Wh.

Conclusion and Outlook

The tests using the simplified model already show an improvement, especially the reduction in used energy. Bigger improvements are expected in wet conditions. The developed controller with dynamic torque distribution in combination with the GNSS/INS sensor will be used in the new car of the Bern Racing Team and tested during the upcoming Formula Students events.

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Figure 1: Bern Racing Team's Formula Student Race Car

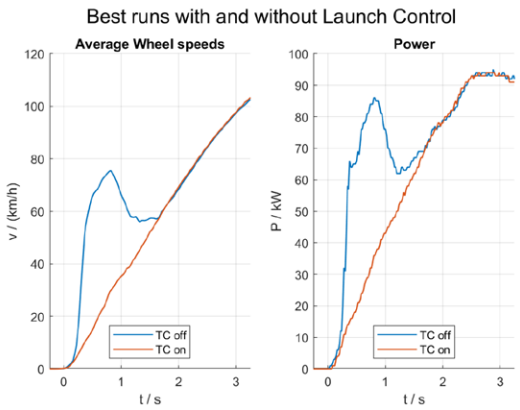

Figure 2: 0-100 km/h Wheel Speed and Power Measurements